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Abstract

NEUTRON-PHYSICAL PARAMETERS OF URANIUM-WATER LATTICES

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The paper deals with the study of $U-H_2O$ lattices having rod-type fuel elements. It presents the results of three independent experiments carried out at the Kurchatov Atomic Energy Institute and certain problems involved in calculation of parameters of uranium-water systems.

1. Critical experiments with lattices at 7, 8 and 14 mm spacings, with and without absorbers, are described. The core consisted of fuel elements similar to those used in the reactors of the icebreaker "LENIN" (diameter of sintered uranium dioxide fuel element - 4.5 mm, enrichment - 5.3%, cladding - 0.3 mm stainless steel or 0.75 mm zirconium). The absorbers were made of a mixture of boron carbide and aluminium oxide in the form of rods from 4.4 mm to 12 mm in diameter. Their "blackness" dE_c varied within the range of 0.75 to 40.

The paper describes the one-group method developed for calculating cores having complex configuration, with corrections for absorption of neutrons in the epithermal region of the spectrum. It is shown that the theoretical and experimental data agree within 10%.

2. An investigation was performed of the parameters of lattices with spacings 13, 15, 17 and 19 mm and with the elements made of sintered dioxide of natural uranium (fuel element diameter - 9.4 mm, cladding - 0.7 mm aluminium). Neutron absorption ratios were measured for various components of the core, as were the fission cross-section ratios of Pu^{239} and U^{235} . The paper presents the values of the multiplication factor K_{∞} , its four co-factors μ, γ, θ, ν eff. and the breeding ratio ρ with the neutron leakage taken into account.

For the 13 mm spaced lattice the value of the material buckling κ^2 was determined from the spatial distribution of neutrons. The full migration area M^2 was measured by the poisoning method as were the migration areas at moderations down to the fission threshold of $U^{238} - M_8^{+2}$ and down to the main resonances of $U^{238} - M_8^{22}$. The form of the critical equation was estimated on the basis of the experimental data and was shown to be close to a one-group equation. Parameters K_∞, μ, ρ , etc. were likewise determined for a dry uranium lattice.

3. A 60 mm spaced lattice with uranium-magnesium ceramic (fuel element diameter - 35 mm, magnesium weight content - 17.8%, enrichment - 2%, cladding - 1 mm aluminium) was subjected to a complex investigation. Using a method of pulsed source the dependence of the neutron flux relaxation time on the height and radius of the assembly was studied in a wide range of the geometrical bucklings (from critical value κ_0^2 to $3\kappa_0^2$). Critical configurations and the corresponding neutron flux distributions were determined. Provision was made for the water reflector to be separated from the assembly by a cadmium sheet.

Parts of the function describing variations of the flux in time and space were determined theoretically, this was important for carrying out the experiment. It was shown that the measurements in uranium-water systems can be analysed using a theory which disregards the correlations between the place and the moment of neutron absorption. The corrections for these correlations and for the heterogeneity and deviations of the capture and fission cross-sections from the law $1/V$ are insignificant.

The anisotropy of the migration area M^2 was detected and the next space moment (r_4) aver. was estimated. Parameters $K_\infty, M_2^2, M_H^2, \kappa_0^2$, life time, radial and axial savings, etc., were also measured.